

Safety Data Sheet

2-Mercaptoethanol

Division of Safety
National Institutes
of Health



WARNING!

THIS COMPOUND IS ACUTELY TOXIC. IT IS READILY ABSORBED THROUGH THE SKIN AND RESPIRATORY AND INTESTINAL TRACTS. IT MAY IRRITATE THE SKIN AND EYES. AVOID FORMATION AND BREATHING OF AEROSOLS OR VAPORS.

LABORATORY OPERATIONS SHOULD BE CONDUCTED IN A FUME HOOD, GLOVE BOX, OR VENTILATED CABINET.

AVOID SKIN CONTACT: IF EXPOSED, WASH WITH SOAP AND COLD WATER. AVOID WASHING WITH SOLVENTS. AVOID RUBBING OF SKIN OR INCREASING ITS TEMPERATURE.

2-ME IS FLAMMABLE. KEEP AWAY FROM SPARKS AND OPEN FLAMES. IN CASE OF FIRE, USE CARBON DIOXIDE OR DRY CHEMICAL EXTINGUISHER.

FOR EYE EXPOSURE, IRRIGATE IMMEDIATELY WITH LARGE AMOUNTS OF WATER. FOR INGESTION, INDUCE VOMITING. DRINK MILK OR WATER. REFER FOR GASTRIC LAVAGE. FOR INHALATION, REMOVE VICTIM PROMPTLY TO CLEAN AIR. ADMINISTER RESCUE BREATHING IF NECESSARY. REFER TO PHYSICIAN.

IN CASE OF LABORATORY SPILL, WEAR PROTECTIVE CLOTHING DURING CLEANUP. AVOID SKIN CONTACT OR BREATHING OF AEROSOLS OR VAPORS. USE WATER TO DISSOLVE COMPOUND. USE ABSORBENT PAPER TO MOP UP SPILL. WASH DOWN AREA WITH SOAP AND WATER. DISPOSE OF WASTE SOLUTIONS AND MATERIALS APPROPRIATELY.

A. Background

2-Mercaptoethanol (2-ME) is a colorless mobile liquid with a faint characteristic odor. It is miscible with water, ethanol, ether, and benzene. It is absorbed by ingestion, inhalation, and through the skin, and acts as powerful eye and skin irritant. Its toxicity by

Issued: 4/85

Prepared by the Environmental
Control and Research Program

oral, dermal, and intravenous administration is high. Industrial uses of 2-ME have not been described, but it is a useful tool in the biochemical laboratory in protein and peptide sequencing studies since disulfide bonds can be cleaved with the least amount of side reactions by means of this reagent. Another use is as a stabilizer during isolation and purification of enzyme systems which require free sulfhydryl groups for activity.

There is no federal standard for exposure to 2-ME, although it has been proposed that production, use, and exposure information be recorded (EPA, 1980). A Russian publication suggests that the maximum permissible concentration in air should be 1 mg/m^3 (Pugaeva et al., 1971).

Chemical and Physical Data

1. Chemical Abstract No.: 60-24-2.
2. Synonyms: -mercaptoethanol; 2-hydroxy-1-ethanethiol; 2-hydroxy-ethyl mercaptan; monothioethylene glycol; thioglycol; 1-ethanol-2-thiol.
3. Chemical structure and molecular weight:
 $\text{HS-CH}_2\text{-CH}_2\text{-OH}$; $\text{C}_2\text{H}_6\text{OS}$; 78.13
4. Density: $d_4^{20} = 1.1143$; vapor density = 2.69.
5. Absorption spectroscopy: 2-ME has a stable ultraviolet absorption maximum in alkaline solution at 235 nm (DeDeken et al., 1956). Infrared and proton NMR spectra have been published (Simons, 1978a, 1978b). (Spectra # 1661).
6. Volatility: The vapor pressure at 20°C is 1 mm Hg (Sax, 1984).
7. Solubility: 2-ME is freely miscible with water, ethanol, ether, and benzene.
8. Description: Water-white mobile liquid with a faint characteristic odor. The pK_a of the sulfhydryl group is 9.6.
9. Boiling point: $157\text{-}158^\circ\text{C}$ at 742 mm Hg (with decomposition), 63°C at 18 mm Hg, 44.5°C at 4 mm Hg; melting point: no data.
10. Stability: Very little information. 2-ME appears to be quite stable in pure form or in aqueous solution in the absence of atmospheric oxygen, at room temperature and neutral and low pH. It is oxidized to the corresponding disulfide in aerated solution, and this reaction is catalyzed by metal (e.g., copper) ions (Stevens et al., 1983). When heated to decomposition, 2-ME emits toxic vapors of sulfur oxides.

11. Chemical reactivity: Both the sulfhydryl and hydroxyl groups are subject to the usual substitution reactions. At 140°C in the presence of an acid catalyst, 2-ME is cyclized to ethylene episulfide. It reacts with oxidants to form disulfide and further oxidation products.
12. Flash point: 74°C (Cleveland open cup) (Sax, 1984).
13. Autoignition temperature: No data.
14. Explosive limits in air: No data.

C. Fire, Explosion, and Reactivity Hazard Data^A

1. Use alcohol foam, carbon dioxide, or dry chemicals as fire extinguishants. While the fire hazards due to heat or flame are small, exposure by inhalation, eye, or skin contact should be avoided. Therefore, fire-fighting personnel should wear air-supplied respirators with full face masks.
2. 2-ME is incompatible with strongly oxidizing materials (depending on the extent of oxidation, the products could be either less or more hazardous than 2-ME itself.)
3. Hazardous decomposition products under conditions of fire are highly toxic sulfur oxides.
4. Do not expose to open flames. Non-spark tools and equipment are not required.

D. Operational Procedures

The NIH Guidelines for the Laboratory Use of Chemical Carcinogens describe operational practices to be followed when potentially carcinogenic chemicals are used in NIH laboratories. The NIH Guidelines should be consulted to identify the proper use conditions required and specific controls to be implemented during normal and complex operations or manipulations involving 2-ME.

It should be emphasized that this data sheet and the NIH Guidelines are intended as starting points for the implementation of good laboratory practices when using this compound. The practices and procedures described in the following sections pertain to the National Institutes of Health and may not be universally applicable to other institutions. Administrators and/or researchers at other institutions should modify the following items as needed to reflect their individual management system and current occupational and environmental regulations.

^AInformation based mainly on Sax (1984).

1. Chemical inactivation: No validated method reported.
2. Decontamination: Turn off equipment that could be affected by 2-ME or the materials used for cleanup. If there is any uncertainty regarding the procedures to be followed for decontamination, call the NIH Fire Department (dial 116) for assistance. Use absorbent paper to mop up spill. After the residue has evaporated, wash surfaces with copious quantities of water. Glassware should be rinsed in a hood with water, followed by soap and water. Animal cages should be washed with water.
3. Disposal: No waste streams containing 2-ME shall be disposed of in sinks or general refuse. Surplus 2-ME or chemical waste streams contaminated with 2-ME shall be handled as hazardous chemical waste and disposed of in accordance with the NIH chemical waste disposal system. Nonchemical waste (e.g., animal carcasses and bedding) containing 2-ME shall be handled and packaged for incineration in accordance with the NIH medical-pathological waste disposal system. Potentially infectious waste (e.g., tissue cultures) containing 2-ME shall be packaged for incineration, as above. Burnable waste (e.g., absorbent bench top liners) minimally contaminated with 2-ME shall be handled as potentially infectious waste and packaged for incineration, as above. Absorbent materials (e.g., associated with spill cleanup) grossly contaminated shall be handled in accordance with the chemical waste disposal system. Radioactive waste containing 2-ME shall be handled in accordance with the NIH radioactive waste disposal system.
4. Storage: Store in sealed ampoules or in bottles with caps with polyethylene cone liners inside a sealed secondary container in an explosion-safe refrigerator. Avoid exposure to light, moisture, and atmospheric oxygen. Store working quantities of 2-ME and its solutions in the dark and under an inert atmosphere in an explosion-safe refrigerator in the work area.

Monitoring and Measurement Procedures Including Direct Field Measurements and Sampling for Subsequent Laboratory Analysis

1. Sampling: No data. Collection of samples for subsequent analysis in silica tubes, with desorption by methanol, has been mentioned as possibly applicable to field analysis but no data are presented (Choudhary, 1980).
2. Analysis: Colorimetric methods are not specific for 2-ME but are generally applicable to aliphatic sulphhydryl compounds. Several are based on the reaction of thiols with "Ellman reagent" (5,5'-dithiobis[2-nitrobenzoic acid]) which produces a color read at 420 nm (Ellman, 1959) and have been applied to the determination of sulphhydryl groups in blood, urine, tissue samples, and purified proteins. A similar method, using as color reagent 2,6-dibromobenzoquinone-4-chloroimide is even less

specific but more sensitive (Stenersen, 1967). Greater specificity can be achieved by use of chromatography, either GLC in the nanogram range (Choudhary, 1980) or more usually by HPLC which is particularly useful for the separation of reduced and oxidized 2-ME (Ingebretsen and Farstad, 1981; Carnevale and Healey, 1982). The most sensitive method to date (though applicable to other sulfhydryl compounds and applied to the determination of SH groups in blood) is the reaction with monobromobimane to form a fluorescent derivative measurable in the picogram range (Newton et al., 1981). Of interest also is a spectrophotometric procedure for the simultaneous determination of reduced and oxidized forms of thiols, based on differences in reaction speed with a palladium reagent (Dupre and Aureli, 1980).

F. Biological Effects (Animal and Man)

1. Absorption: 2-ME is absorbed by inhalation, ingestion, parenteral injection, and through the skin. It produces necrotizing effects on contact with the eye but there is no indication whether systemic effects are produced via this route.
2. Distribution: No data.
3. Metabolism and excretion: Only one pertinent reference has been found and this has been seen in abstract form only (Federici et al., 1976.) According to these authors, ³⁵S-labeled 2-ME on intraperitoneal injection is rapidly metabolized into five or more metabolites which are excreted rapidly in the urine (99% within 2 days); the major metabolite is inorganic sulfate, with a small amount of isethanoic acid ($\text{HOCH}_2\text{CH}_2\text{SO}_3\text{H}$). In purified tissue preparations, the oxidation by NAD (Lambe and Williams, 1965) and the S-methylation by S-adenosyl methionine (Bremer and Greenberg, 1961) has been demonstrated.
4. Toxic effects:^A Intraperitoneal and oral LD50 in the mouse and rat is in the range of 200-350 mg/kg, and the percutaneous toxicity in the guinea pig is in the same range. No deaths were produced by exposure of rats to an air stream saturated with 2-ME in 4 hours (Smyth and Carpenter, 1944). Acute effects of parenteral 2-ME (~ 1.5 LD50) in rats produced tremors, convulsions, respiratory failure, and death within 1-2 hours, with no histopathological changes. At doses near the LD50 there were minimal changes in liver and kidney and marked depression, possibly due to formation of toxic metabolites. Skin effects in the rabbit (Draize test) were moderate erythema and edema within

^A2-ME has been mentioned as a possible reaction product in the sterilization of sulfur-containing rubber medical devices with ethylene oxide.

24 hours which had disappeared after 72 hours in unabraded skin lasting longer on abraded skin. Intracutaneous diluted 2-ME produced marked inflammation and necrosis (White et al., 1973). Eye effects of undiluted or diluted 2-ME consisted of corneal irritation and necrosis with prolonged healing periods (Carpenter and Smyth, 1946). No symptoms of intoxication in man have been described.

5. Carcinogenic effects: None has been reported; on the contrary prolonged administration of 2-ME in the diet of rats over a 2.5 year period postponed the onset and decreased the incidence of tumors, indicative of a potential decrease in free radical accumulation due to the reductive effect of 2-ME (Heidrick et al., 1984).
6. Mutagenic and teratogenic effects: none has been reported.

Emergency Treatment

1. Skin and eye exposure: For skin exposure, remove contaminated clothing and wash skin with soap and water. Skin should not be rinsed with organic solvents. Since 2-ME is readily absorbed through the skin, avoid rubbing of skin or increasing its temperature. For eye exposure, irrigate immediately with copious quantities of running water for at least 15 minutes. Obtain ophthalmological evaluation.
2. Ingestion: Drink plenty of water or milk. Induce vomiting. Refer for gastric lavage.
3. Inhalation: Remove victim promptly to clean air. Administer rescue breathing if necessary.
4. Refer to physician.

References

- Bremer, J. and D.M. Greenberg. 1961. Enzymic methylation of foreign sulfhydryl compounds. *Biochim Biophys Acta* 46:217-224.
- Carnevale, I. and K. Healey. 1982. Determination of thiols by titrimetric and chromatographic procedures based on reactions with aromatic thiosulfonates. *Anal Chim Acta* 140:143-151.
- Carpenter, C.P. and H.F. Smyth Jr. 1946. Chemical burns of the rabbit cornea. *Am J Ophthalmol* 29:1363-1372.
- Choudhary, C. 1980. Gas-liquid chromatography of 2-mercapto-ethanol. *J Chromatog* 200:211-215.
- DeDeken, K.H., J. Broeckhuysen, J. Béchet, and A. Mortier. 1956. Etude spectrophotométrique de la dissociation de la fonction sulfhydryle et structure moléculaire de la cystéine. [Spectrophotometric study of the dissociation of the sulfhydryl group, and molecular configuration of cysteine.] *Biochim Biophys Acta* 12:15-22.

- Dupré, S. and M. Aureli. 1980. Simultaneous spectrophotometric determination of oxidized and reduced forms of thiols in solution. *Anal Biochem* 105:97-100.
- Ellman, G.L. 1959. Tissue sulfhydryl groups. *Arch Biochem Biophys* 82:70-77.
- EPA. 1980. Environmental Protection Agency. Pesticides and toxic substances; general recordkeeping and recording requirements. Preliminary assessment information. *Fed Reg* 45:13646.
- Federici, G., G. Ricci, S. Dupré, A. Antonucci, and D. Cavallini. 1976. The metabolism of mercaptoethanol by the living rat. *Biochem Exp Biol* 12:341-345; *Chem Abstr* 87:115283h.
- Heidrick, M.L., L.C. Hendricks, and D.E. Cook. 1984. Effect of dietary 2-mercaptoethanol on the life span, immune system, tumor incidence and lipid peroxidation damage in spleen lymphocytes of aging BC3F mice. *Mech Age Dev* 27:341-358.
- Ingebretsen, O.C. and M. Farstad. 1981. Separation of the oxidized and reduced forms of dithiothreitol and 2-mercaptoethanol by reversed-phase high-performance liquid chromatography. Application of the method to biological extracts and to the determination of disulphides. *J Chromatog* 210:522-526.
- Lambe, R.F. and D.C. Williams. 1965. The enzymic reduction of nicotinamide-adenine dinucleotide by 2-mercaptoethanol. *Biochem J* 97:475-478.
- Newton, G.L., R. Dorian, and R.C. Fahey. 1981. Analysis of biological thiols: derivatization with monobromobimane and separation by reverse-phase high-performance liquid chromatography. *Anal Biochem* 114:383-387.
- Pugaeva, V.P., S.I. Klochkova, F.D. Mashbits, and R.S. Eisengart. 1971. Materials for setting up hygienic standards for the level of B-hydroxyethyl mercaptan in the air of industrial premises. *Gig Tr Prof Zabol* 15:56-58; *Chem Abstr* 74:130069t.
- Sax, N.I. 1984. *Dangerous Properties of Industrial Materials*, 6th ed. Van Nostrand Reinhold Co., New York, NY.
- Simons, W.W. (ed). 1978a. *Sadtler Handbook of Infrared Spectra*. Sadtler Research Laboratories, Philadelphia, PA.
- Simons, W.W. (ed). 1978b. *Sadtler Handbook of Proton NMR Spectra*. Sadtler Research Laboratories, Philadelphia, PA.
- Smyth, H.F., Jr. and C.P. Carpenter. 1944. The place of the range finding test in the industrial toxicology laboratory. *J Ind Hyg Toxicol* 26:269-273.
- Stenersen, J.H.V. 1967. 2,6-Dibromobenzoquinone-4-chloroimide as a reagent for determination of Dimethoate, monoalkyl-aryl-phosphorothionates and some organic sulfides. *Bull Environ Contam Toxicol* 2:364-371.
- Stevens, R., L. Stevens, and N.C. Price. 1983. The stabilities of various thiol compounds used in protein purification. *Biochem Educ* 11:70; *Chem Abstr* 99:101879t.
- White, K., J.V. Bruckner, and W.L. Guess. 1973. Toxicological studies of 2-mercaptoethanol. *J Pharm Sci* 62:237-241.